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CofC



Docket No.: 07700/066001  
(PATENT)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Letters Patent of:  
Hideo Morimoto

Patent No.: 7,360,456

Issued: April 22, 2008

For: MULTI-AXIS SENSOR

**REQUEST FOR CERTIFICATE OF CORRECTION  
PURSUANT TO 37 CFR 1.322**

Attention: Certificate of Correction Branch  
Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450

Dear Sir:

Upon reviewing the above-identified patent, Patentee noted typographical errors which should be corrected.

In the Claims:

In Claim 2, column 27, line 5, "in" should be --is--.

In Claim 11, column 28, line 22, "tat" should be --that--.

The errors were not in the application as filed by applicant; accordingly no fee is required.

Transmitted herewith is a proposed Certificate of Correction effecting such amendment. Also enclosed, as evidence of the error, is a copy of the claims as issued, and a

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JUL - 1 2008

Patent No.: 7,360,456


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copy of the Amendments to the Claims. Patentee respectfully solicits the granting of the requested Certificate of Correction.

Applicant believes no fee is due with this request. However, if a fee is due, please charge our Deposit Account No. 50-0591, under Order No. 07700/066001.

Dated: June 24, 2008

Respectfully submitted,

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JUL - 1 2008

[FIG. 23]

A central vertical sectional front view showing a multi-axial sensor according to a sixth embodiment.

[FIG. 24]

A plan view showing the arrangement of strain gauges when the multi-axial sensor according to the sixth embodiment is transparently viewed in the reverse direction of the Z axis.

[FIG. 25]

A central vertical sectional front view showing displacement when an acceleration  $a_x$  is applied to the multi-axial sensor.

[FIG. 26]

A plan view showing changes in the resistance values of the strain gauges when the acceleration  $a_x$  is applied to the multi-axial sensor.

[FIG. 27]

A central vertical sectional front view showing displacement when an acceleration  $a_z$  is applied to the multi-axial sensor.

[FIG. 28]

A plan view showing changes in the resistance values of the strain gauges when the acceleration  $a_x$  is applied to the multi-axial sensor.

[FIG. 29]

A central vertical sectional front view showing displacement when an angular acceleration  $\alpha_y$  is applied to the multi-axial sensor.

[FIG. 30]

A plan view showing changes in the resistance values of the strain gauges when the angular acceleration  $\alpha_y$  is applied to the multi-axial sensor.

[FIG. 31]

A plan view showing changes in the resistance values of the strain gauges when an angular acceleration  $\alpha_z$  is applied to the multi-axial sensor.

[FIG. 32]

Circuit diagrams showing examples of bridge circuits for the multi-axial sensor.

[FIG. 33]

Circuit diagrams showing examples of bridge circuits according to a seventh embodiment.

[FIG. 34]

A plan view showing a multi-axial sensor according to an eighth embodiment.

[FIG. 35]

A central vertical sectional front view showing the multi-axial sensor according to the eighth embodiment.

[FIG. 36]

A central vertical sectional front view showing a multi-axial sensor according to a ninth embodiment.

[FIG. 37]

A plan view showing the arrangement of strain gauges when a multi-axial sensor according to the ninth embodiment is Z-axially transparently viewed from the position of a second member.

[FIG. 38]

A central vertical sectional front view showing displacement when a force  $F_x$  is applied to the multi-axial sensor.

[FIG. 39]

A plan view showing changes in the resistance values of the strain gauges when the force  $F_x$  is applied to the multi-axial sensor.

[FIG. 40]

A central vertical sectional front view showing displacement when a force  $F_z$  is applied to the multi-axial sensor.

[FIG. 41]

A plan view showing changes in the resistance values of the strain gauges when the force  $F_z$  is applied to the multi-axial sensor.

[FIG. 42]

A central vertical sectional front view showing displacement when a force  $M_x$  is applied to the multi-axial sensor.

[FIG. 43]

A plan view showing changes in the resistance values of the strain gauges when the force  $M_x$  is applied to the multi-axial sensor.

[FIG. 44]

A plan view showing changes in the resistance values of the strain gauges when a force  $M_z$  is applied to the multi-axial sensor.

[FIG. 45]

Circuit diagrams showing examples of bridge circuits for the multi-axial sensor.

[FIG. 46]

A circuit diagram showing an example of a dummy circuit.

[FIG. 47]

A plan view showing the arrangement of strain gauges when a multi-axial sensor according to a tenth embodiment is Z-axially transparently viewed from the position of a second member.

[FIG. 48]

Circuit diagrams showing examples of bridge circuits according to the tenth embodiment.

[FIG. 49]

A perspective view showing a prior art multi-axial sensor.

## DESCRIPTION OF REFERENCE NUMERAL

- 1: multi-axial sensor
- 2: first member
- 3: second member
- 4, 5, 6, 7: diaphragm
- 8: central shaft
- 10: piezoresistance element
- 16, 17, 18, 19: operative body
- R11 to R48, R111 to R148: strain gauge

The invention claimed is:

1. A 6-axis sensor for measuring 6-axis forces and moments or 6-axis accelerations and angular accelerations, externally applied, characterized by comprising:

- a plurality of strain gauges disposed on one plane;
  - a plurality of first diaphragms to which the plurality of strain gauges are attached;
  - a first member comprising one of the plurality of first diaphragms;
  - a second member comprising a second diaphragm opposed to the one of the plurality of first diaphragms and provided with a plurality of strain gauges disposed on one plane; and
  - a connecting shaft connecting the opposed first and second diaphragms;
- wherein the plurality of first diaphragms are arranged around a central point of the plane at regular angular intervals and at the same distance from the central point;

6-axis forces and moments applied between the first and second members are measured;

the strain gauges of the first member and the strain gauges of the second member are disposed symmetrically with respect to a barycentric point of the 6-axis sensor; and

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either outputs of the strain gauges of the first member and the strain gauges of the second member are adopted if the other outputs are out of a predetermined range.

\* 2. The 6-axis sensor according to claim 1, characterized in that the angular interval in 90 degrees.

3. The 6-axis sensor according to claim 1, characterized in that the diaphragms are disposed in positive and negative direction on X and Y axes with an origin being defined at the central point.

4. The 6-axis sensor according to claim 1, characterized in that the angular interval is 120 degrees.

5. The 6-axis sensor according to claim 1, characterized in that a thin portion of each of the plurality of first diaphragms is annular and provided with eight strain gauges, and

the strain gauges are disposed at outer and inner edge portions of each of the plurality of first diaphragms on a line extending between a central point of each of the plurality of first diaphragms and the central point of the plane, and at outer and inner edge portions of each of the plurality of first diaphragms on a line perpendicular to the former line at the central point of each of the plurality of first diaphragms.

6. The 6-axis sensor according to claim 1, characterized in that the 6-axis sensor further comprises an operative body provided on a central portion of one or more of the plurality of first diaphragms, and

6-axis accelerations and angular accelerations applied to the 6-axis sensor are measured.

7. The 6-axis sensor according to claim 1, characterized in that each of the strain gauges is made of a piezoresistance element.

8. The 6-axis sensor according to claim 1, characterized in that each of the strain gauges is made of a thin film of chromium oxide formed on an insulating film.

9. A 6-axis sensor for measuring 6-axis forces and moments or 6-axis accelerations and angular accelerations, externally applied, the 6-axis sensor comprising:

a plurality of strain gauges disposed on one plane;  
a plurality of first diaphragms to which the plurality of strain gauges are attached;

wherein only one of the plurality of first diaphragms is disposed on the plane;

a first member comprising one of the plurality of first diaphragms;

a second member comprising a second diaphragm provided with a plurality of strain gauges disposed on one plane; and

operative bodies connecting the first and second diaphragms,

wherein the first and second members are disposed so that a central point of the first diaphragm of the first member is opposed to a central point of the second diaphragm of the second member,

wherein the operative bodies connects the first and second diaphragms at positions arranged around the central points of the first and second diaphragms at regular angular intervals and at the same distance from the central points, and 6-axis forces and moments applied between the first and second members are measured, wherein the strain gauges of the first member and the strain gauges of the second member are disposed symmetrically with respect to a barycentric point of the 6-axis sensor, and

wherein either outputs of the strain gauges of the first member and the strain gauges of the second member are adopted if the other outputs are out of a predetermined range.

10. The 6-axis sensor according to claim 9, characterized in that the angular interval is 90 degrees.

\* 11. The 6-axis sensor according to claim 9, characterized in that the operative bodies are disposed in positive and negative directions on X and Y axes with an origin being defined at the central point of the first diaphragm.

12. The 6-axis sensor according to claim 9, characterized in that the angular interval is 120 degrees.

13. The 6-axis sensor according to claim 9, characterized in that the strain gauges are disposed:

at edge portions of the operative bodies on a line extending between a central point of a portion on the plane corresponding to the operative bodies, and the central point of the first diaphragm;

at edge portions of the operative bodies on a line perpendicular to the former line at the central point of the portion on the plane corresponding to the operative bodies; and

at either of edge portions of the operative bodies and edge portions of the first diaphragm, at positions arranged around the central point of the first diaphragm at regular angular intervals and at the same distance from the central point.

14. The 6-axis sensor according to claim 9, characterized in that each of the strain gauges is made of a piezoresistance element.

15. The 6-axis sensor according to claim 9, characterized in that each of the strain gauges is made of a thin film of chromium oxide formed on an insulating film.

\* \* \* \* \*

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**AMENDMENTS TO THE CLAIMS**

Please amend the claims as follows.

1. (Currently Amended) A 6-axis sensor for measuring 6-axis forces and moments or 6-axis accelerations and angular accelerations, externally applied, characterized by comprising:
  - a plurality of strain gauges disposed on one plane; ~~and~~
  - a plurality of first diaphragms to which the plurality of strain gauges are attached;
  - a first member comprising one of the plurality of first diaphragms;
  - a second member comprising a second diaphragm opposed to the one of the plurality of first diaphragms and provided with a plurality of strain gauges disposed on one plane; and
  - a connecting shaft connecting the opposed first and second diaphragms;wherein the plurality of first diaphragms are arranged around a central point of the plane at regular angular intervals and at the same distance from the central point;  
6-axis forces and moments applied between the first and second members are measured;  
the strain gauges of the first member and the strain gauges of the second member are disposed symmetrically with respect to a barycentric point of the 6-axis sensor;  
and  
either outputs of the strain gauges of the first member and the strain gauges of the second member are adopted if the other outputs are out of a predetermined range.
2. (Canceled)
3. (Canceled)
4. (Previously Presented) The 6-axis sensor according to claim 1, characterized in that the ~~angular interval is 90 degrees.~~
5. (Previously Presented) The 6-axis sensor according to claim 1, characterized in that the diaphragms are disposed in positive and negative directions on X and Y axes with an origin being defined at the central point.

6. (Previously Presented) The 6-axis sensor according to claim 1, characterized in that the angular interval is 120 degrees.

7. (Previously Presented) The 6-axis sensor according to claim 1, characterized in that a thin portion of each of the plurality of first diaphragms is annular and provided with eight strain gauges, and

the strain gauges are disposed at outer and inner edge portions of each of the plurality of first diaphragms on a line extending between a central point of each of the plurality of first diaphragms and the central point of the plane, and at outer and inner edge portions of each of the plurality of first diaphragms on a line perpendicular to the former line at the central point of ~~the~~ each of the plurality of first diaphragms.

8. (Previously Presented) The 6-axis sensor according to claim 1, characterized in that the 6-axis sensor further comprises an operative body provided on a central portion of one or more of the plurality of first diaphragms, and

6-axis accelerations and angular accelerations applied to the 6-axis sensor are measured.

9. (Canceled)

10. (Canceled)

11. (Canceled)

12. (Canceled)

13. (Canceled)

14. (Canceled)

15. (Canceled)

16. (Previously Presented) A 6-axis sensor for measuring 6-axis forces and moments or 6-axis accelerations and angular accelerations, externally applied, the 6-axis sensor comprising:

a plurality of strain gauges disposed on one plane;

a plurality of first diaphragms to which the plurality of strain gauges are attached;

wherein only one of the plurality of first diaphragms is disposed on the plane;  
a first member comprising one of the plurality of first diaphragms;  
a second member comprising a second diaphragm provided with a plurality of strain gauges disposed on one plane; and  
operative bodies connecting the first and second diaphragms,  
wherein the first and second members are disposed so that a central point of the first diaphragm of the first member is opposed to a central point of the second diaphragm of the second member,  
wherein the operative bodies connects the first and second diaphragms at positions arranged around the central points of the first and second diaphragms at regular angular intervals and at the same distance from the central points, and 6-axis forces and moments applied between the first and second members are measured,  
wherein the strain gauges of the first member and the strain gauges of the second member are disposed symmetrically with respect to a barycentric point of the 6-axis sensor, and  
wherein either outputs of the strain gauges of the first member and the strain gauges of the second member are adopted if the other outputs are out of a predetermined range.

17. (Canceled)

18. (Canceled)

19. (Canceled)

20. (Canceled)

21. (Canceled)

22. (Canceled)

23. (Previously Presented) The 6-axis sensor according to claim 1, characterized in that each of the strain gauges is made of a piezoresistance element.

24. (Previously Presented) The 6-axis sensor according to claim 1, characterized in that each of the strain gauges is made of a thin film of chromium oxide formed on an insulating film.
25. (Canceled)
26. (Canceled)
27. (Previously Presented) The 6-axis sensor according to claim 16, characterized in that the angular interval is 90 degrees.
28. (Previously Presented) The 6-axis sensor according to claim 16, characterized in that the ~~operative~~ operative bodies are disposed in positive and negative directions on X and Y axes with an origin being defined at the central point of the first diaphragm.
29. (Previously Presented) The 6-axis sensor according to claim 16, characterized in that the angular interval is 120 degrees.
30. (Previously Presented) The 6-axis sensor according to claim 16, characterized in that the strain gauges are disposed:
- at edge portions of the operative bodies on a line extending between a central point of a portion on the plane corresponding to the operative bodies, and the central point of the first diaphragm;
  - at edge portions of the operative bodies on a line perpendicular to the former line at the central point of the portion on the plane corresponding to the operative bodies;
  - and
  - at either of edge portions of the operative bodies and edge portions of the first diaphragm, at positions arranged around the central point of the first diaphragm at regular angular intervals and at the same distance from the central point.
31. (Previously Presented) The 6-axis sensor according to claim 16, characterized in that each of the strain gauges is made of a piezoresistance element.
32. (Previously Presented) The 6-axis sensor according to claim 16, characterized in that each of the strain gauges is made of a thin film of chromium oxide formed on an insulating film.



**UNITED STATES PATENT AND TRADEMARK OFFICE  
CERTIFICATE OF CORRECTION**Page 1 of 1

PATENT NO. : 7,360,456  
APPLICATION NO. : 10/560,995  
ISSUE DATE : April 22, 2008  
INVENTOR(S) : Hideo Morimoto

It is certified that an error appears or errors appear in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

**In the Claims:**

In Claim 2, column 27, line 5, "in" should be --is--.

In Claim 11, column 28, line 22, "tat" should be --that--.

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Application No. (if known): 10/560,995

Attorney Docket No.: 07700/066001

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